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Rocky Mountain Forest and Range Experiment Station

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Research Paper RM-308

Simulation of Management Options for Stands of Southwestern Ponderosa Pine Attacked by Armillaria Root Disease and Dwarf Mistletoe

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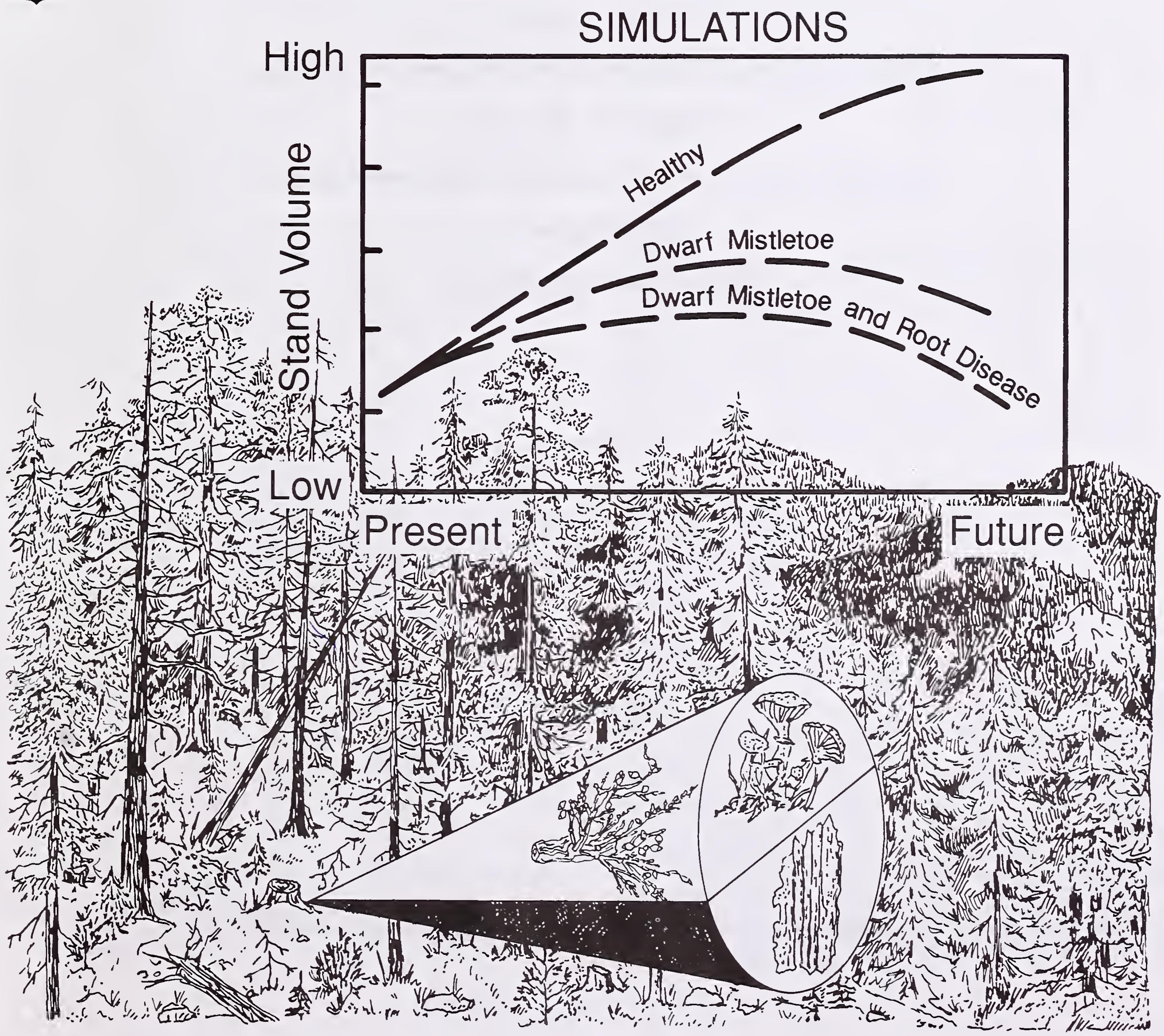

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Abstract

Armillaria spp. is a major cause of root disease in confireous forests in northern New Mexico. In this paper, we examined various management options, including stump removal, for dealing with *Armillaria*. These examinations were made using the Western Root Disease Model.

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Introduction

Root diseases affect the productivity of various forested lands in Arizona and New Mexico. For example, 34% of the tree mortality on 6 National Forests in these states was directly caused by or associated with root disease (Wood 1983). In Wood's survey, *Armillaria* spp., was the most prevalent and serious pathogen, being associated with 75% of the mortality (Wood 1983). *Armillaria* spp. is a major cause of root disease in coniferous forests throughout western North America (Shaw and Kile 1991; Williams et al. 1989).

Armillaria spp. was identified as damaging to ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engelm.) regeneration on the Jemez Ranger District of the Santa Fe National Forest in northern New Mexico more than 50 years ago (Gill 1940). In this same area, Armillaria root disease significantly reduced survival of ponderosa pine planted in the Los Conchas plantation (Weiss 1973; Weiss and Riffle 1971).

In response to this damage, Wood (1982) surveyed about 500 acres of natural forest near the Los Conchas plantation, along New Mexico State Highway #4 (fig. 1). Losses to *Armillaria* spp. were significant. Substantial mortality was recorded in sawtimber (9.8%), and pole- and sapling-sized trees (12%). Wood (1982) suggested some management alternatives to deal with the root disease situation, including various harvest options and possible stump removal operations. The latter have been successfully used to combat *Armillaria* in somewhat similar stands of ponderosa pine in central Washington State (Roth et al. 1977).

In this paper we examine various management options, including stump removal, for dealing with *Armillaria*. These examinations were made by using the Western Root Disease Model (Stage et al. 1990) to simulate future stand and root disease dynamics. Our objective was to demonstrate use of the Western Root Disease Model as a new management tool in the Southwest to rank the relative suitability of the various management options for reducing disease losses. At present, there is not sufficient data on silvicultural treatments of southwestern ponderosa pine infected with *Armillaria* to evaluate field performance of the Western Root Disease Model. We believe, however, that components of the model sufficiently represent real conditions. As such, model simulations are useful indicators for comparison among various silviculture treatments. Furthermore, this study area will be remeasured to provide the necessary data to evaluate the model's performance.

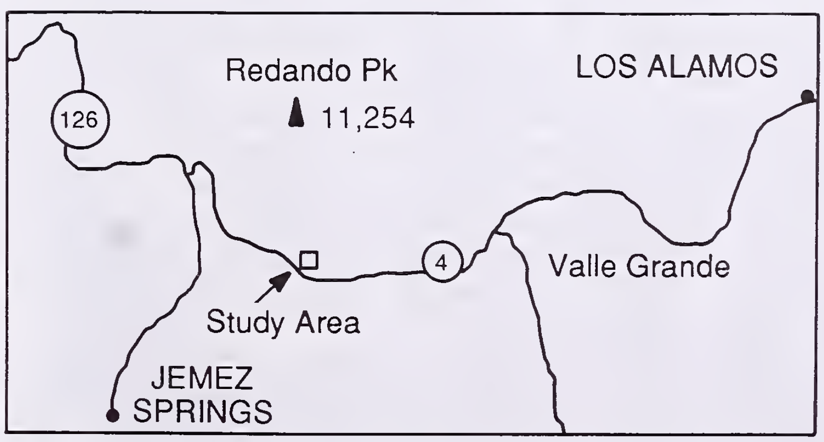

Figure 1.—Integrated Forest Protection Demonstration Area on the Jemez District of the Santa Fe National Forest, New Mexico.

Methods

Sample stands are near state Highway #4 (fig. 1) in a tract designated as an Integrated Forest Protection Demonstration Area (IFPDA). This IFPDA was established as part of a legal settlement concerning management of yet another forest pest, the Western spruce budworm (*Choristoneura occidentallis* Freeman), in New Mexico (Brown et al. 1986). Dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawksworth and Wiens) also is moderate to severe in the area.

Four stands, 12-37 acres in size, were inventoried using procedures of the Southwestern Region (USDA Forest Service 1985), expanded to collect data on the status of root disease. Sample points were systematically located along transect lines within each stand. For stand 103, the largest stand in the evaluation, 20 sample points were taken; only 10 points were taken in each of the other three stands. Both a fixed area, circular plot and a prism plot were established at each point. Trees under 5 inches dbh were measured on the fixed area plot; those 5 inches dbh or larger were measured on the prism plot. The fixed area plots were 1/100 acres. A basal area factor of either 10 or 20 was used for the prism plots depending on stand density.

In addition to standard tree measurements (species, diameter, height, etc.), root disease status was noted. It was recorded as severe if a tree showed basal symptoms or signs of *Armillaria* (Morrison et al. 1991); as infected if it had crown symptoms typical of root disease, but no basal indicators (Morrison et al. 1991); or as uninfected

if neither of the above were present. For modeling purposes (Stage et al. 1990), the latter trees received an infection code if they were within 30 feet of a tree with basal indicators of infection. Recently killed trees and stumps were also examined and recorded as infected if they had basal indicators suggestive of prior attack by *Armillaria*. Additional root disease data were collected in these stands for other purposes (Marsden and Shaw, unpublished), but only the above basic data were used to drive the simulations. Thus, these analyses can serve as examples for other stands on the Jemez Ranger District that lack intensive pest data. The results of this study are not intended as a recommendation for treatment of southwestern ponderosa pine. The stands evaluated are not a random sample of conditions on the Jemez Ranger District. The sample stands are used to demonstrate the use of the Western Root Disease Model to evaluate potential silviculture options in ponderosa pine stands infected with *Armillaria*.

Three stand management options were simulated: no action; harvest without pest suppression; and harvest with pest suppression. Both overstory removal and clearcutting were simulated with various levels of pest suppression. The latter included removal of newly created stumps following harvest, and planting resistant species. Although several combinations of these harvest options and pest suppression actions are possible, only a few example simulations are presented here. To demonstrate the importance of modeling the effect of disease in the simulation of these stands, a set of three base simulations are made. The three conditions simulated are the stand free of either disease, a stand with the level of dwarf mistletoe found at the time of inventory, and a stand with dwarf mistletoe and the estimated level of root disease. Following these simulations, the silvicultural option for each stand is simulated. Stand 203 is left untreated, 104 is clearcut, 103 and 402 are thinned from above. The removal of infected stumps following a stand entry is an added simulation for stands 104, 103, and 402.

To obtain these simulations, the Western Root Disease Model (Stage et al. 1990) was linked to a stand model derived from the GENGYM (Edminster et al. 1991) and Prognosis (Stage 1973; Wycoff et al. 1982) growth and yield models. Tree growth and mortality relationships for conifers in the Southwest were extracted from GENGYM and embedded in a Prognosis model format.[3] This southwest variant of the Prognosis stand growth model also captures effects of infection by dwarf mistletoe through modified growth and mortality functions. Since the Western Root Disease Model includes a submodel for bark beetles[4], a stand level, multi-pest simulation would be possible. However, for simplicity, only dwarf mistletoe and root disease are considered here.

[3]Dixon, G. Central Rockies variant of the Stand Prognosis model. Unnumbered report from WOTM Service Center, December 16, 1991.

[4]Shaw, Charles G. III; Eav, Bov B. [In press]. Modeling interactions among bark beetles, root pathogens, and conifers. In: Schowalter, M.; Filip, G., eds. Beetle-pathogen interactions in conifers. New York: Academic Press.

In the southwestern ponderosa pine variant of Prognosis, dwarf mistletoe effects are automatically simulated if the disease is recorded in the inventory data. Root disease is simulated only if specifically requested by the user.

The Western Root Disease Model allows users to partition root disease into specific centers within a stand, or to simulate the entire stand as if it were all within one disease center. Since root-diseased trees were present throughout these stands, we used the latter option. After simulation of timber and stump removal, the distribution of infected trees after four, 5-year growth cycles redefines stand area within root disease centers (Stage et al. 1990).

Results and Discussion

The four stands have a large component of mature ponderosa pine (*Pinus ponderosa* var. *scopulorum*) with a mixture of some Douglas-fir (*Pseudotsuga menziesii*), aspen (*Populus tremuloides* Michx.) and other hardwoods. Stand 103 is the largest at 37 acres. It has approximately 3,400 trees per acre with a merchantable volume of 8,600 board feet per acre. The volume is 92% ponderosa pine. Stand 104 is 21 acres. It has about 4,100 trees per acre with a volume of nearly 15,000 board feet per acre. The volume is chiefly ponderosa pine (91%) with some Douglas-fir (4%). The rest is aspen or other hardwoods. Stand 203 is only 12 acres. It has 4,300 trees per acre with a volume of over 19,000 board feet per acre in ponderosa pine. Stand 402 is 18 acres. It has 3,300 trees per acre with a volume of about 9,000 board feet per acre. The volume is 96% ponderosa pine and 4% Douglas-fir.

Three simulations are presented for stand 203, five each for stands 104, 103, and 402. To evaluate basic effects of disease, each stand was modeled without consideration for effects of dwarf mistletoes or root disease, with dwarf mistletoe alone, and with both dwarf mistletoe and root disease. The amount of dwarf mistletoe differed among stands while root disease was more evenly distributed within all stands. The size and distribution by species of trees did differ among stands, affecting the potential for impact from root disease.

In a simulation of a healthy stand, free of both dwarf mistletoe and root diseases, stand 103 is projected to increase in volume to 32,000 board feet per acre in 80 years (fig. 2). At this stage, the stand would be mostly pole- and sawtimber-sized trees. Few stands in the Jemez area reach this volume. Dwarf mistletoe alone in the stand would reduce the projected volume to less than half that for the simulated "healthy" stand. Root disease in the stand would again cut the projected volume by half (fig. 2).

Dwarf mistletoe is predicted to both spread and intensify within the stand. This would cause high mortality among small trees—thus preventing large numbers of them from reaching the pole size class. To a lesser extent, it also would reduce the sawtimber class. The projected diameter distribution for this stand for

1990 and for 70 years later appear in figs. 3 and 4. Projections with and without dwarf mistletoe appear in fig. 4.

Simulations of stands 203, 402, and 104 follow the same pattern as stand 103 (figs. 5, 6 and 7). Without either disease, projected stand volumes would greatly increase over the next 80 years. With these diseases considered, projected volume in 80 years will be considerably less than volume in 1990. This expected decline in volume may be somewhat overestimated because natural regeneration within the openings created by tree mortality is not simulated. Perhaps a few such trees would reach sufficient size to contribute meaningful volume.

Overstory removal with removal of newly created, infected stumps is a management option recommended for some stands in the area. Harvest of trees 9 inches and greater in diameter is modeled with and without such stump removal. In these scenarios, simulated volume is recovered, small trees are released, and some disease sources are eliminated for stands 103 and 402.

From each stand, the volume removed in 1990 is near 10,000 board feet per acre. The effect on the distribution of root disease in the stand is simulated over the following 20 years. The initial stand was specified as having root disease scattered throughout the entire stand area. The model recalculated the infected area based on locations of infected trees following a stand entry. The projected stand then has a new estimate of area infected for the year 2020, but this

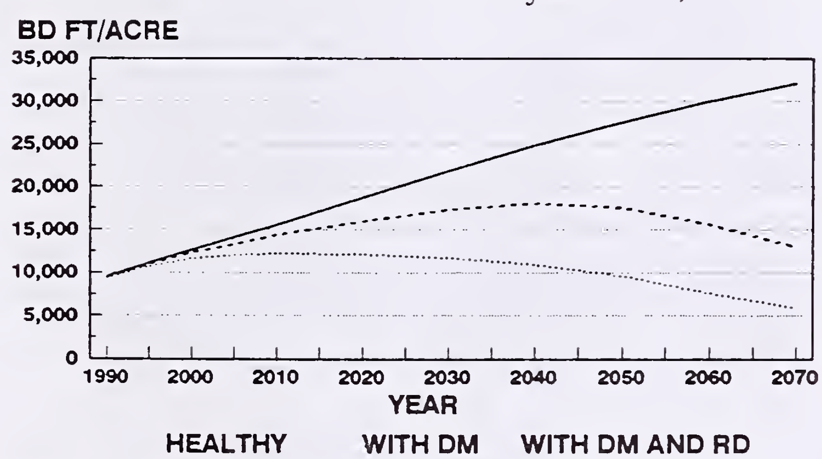

Figure 2.—Stand 103, volume simulation with and without disease impacts (DM=dwarf mistletoe, RD=root disease).

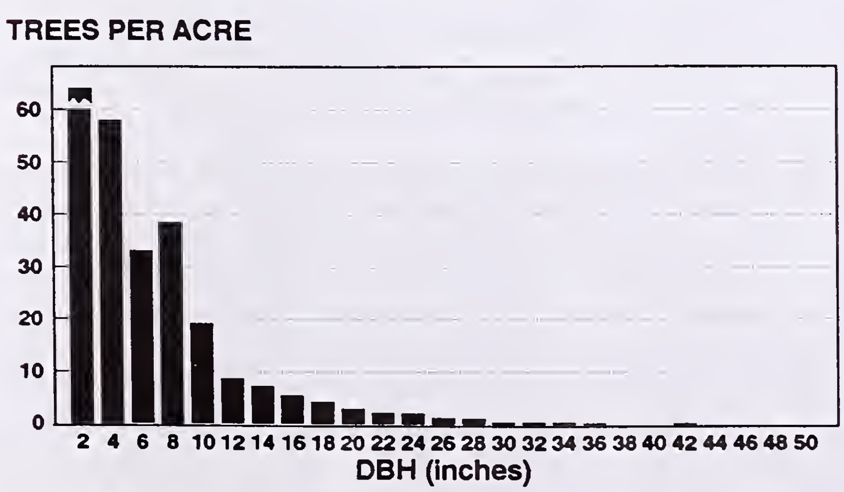

Figure 3.—Stand 103, diameter distribution in 1990. There were 564 trees per acre in the 2-inch class.

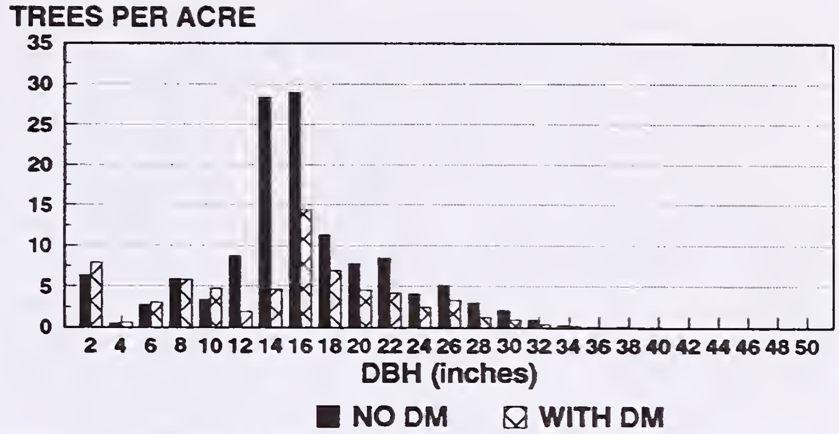

Figure 4.—Stand 103, simulated diameter distribution by year 2060, with and without the impact of dwarf mistletoe (DM=dwarf mistletoe, RD=root disease).

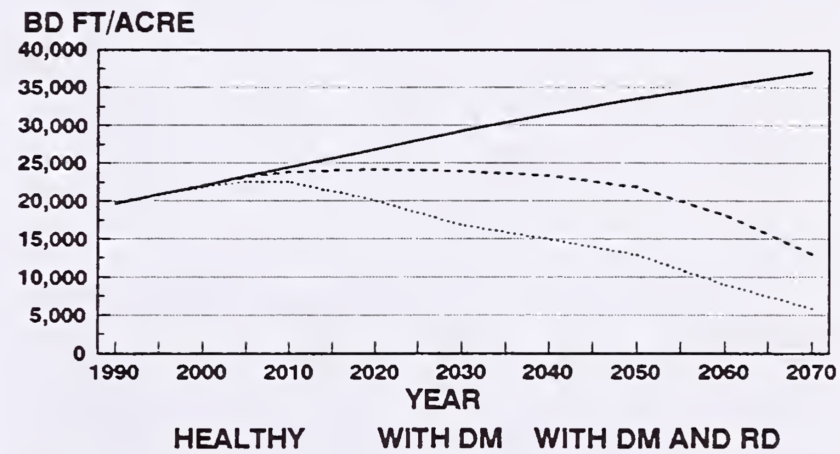

Figure 5.—Stand 203, volume simulation with and without disease impacts (DM=dwarf mistletoe, RD=root disease).

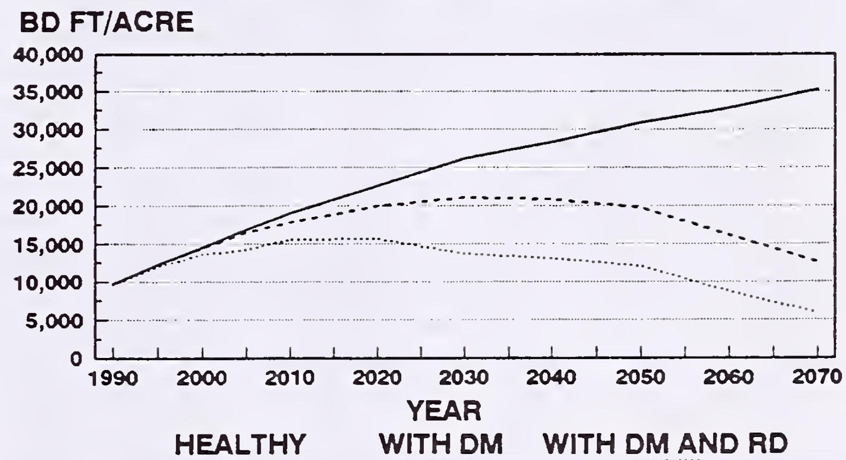

Figure 6.—Stand 402, volume simulation with and without disease impacts (DM=dwarf mistletoe, RD=root disease).

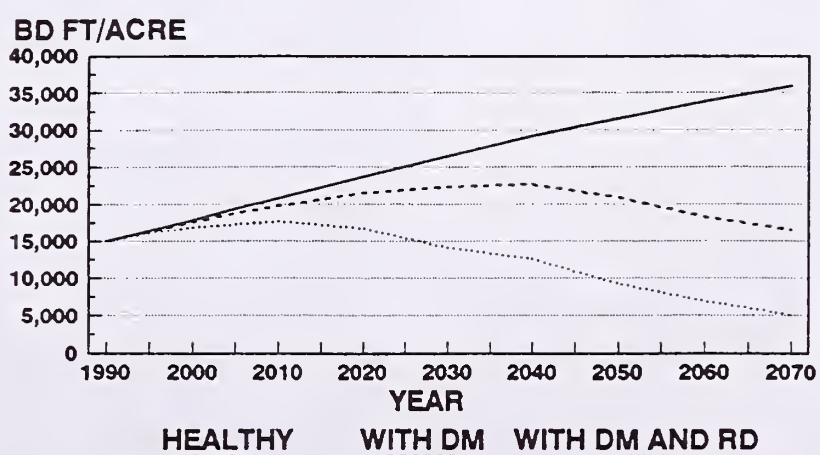

Figure 7.—Stand 104, volume simulation with and without disease impacts (DM=dwarf mistletoe, RD=root disease).

represents many small infected areas scattered throughout the stand. Removal of infected stumps should further reduce the total area infected in each stand.

Effects of overstory removal can be seen in figs. 8 and 9. The pattern is the same for both stands in that volume is reduced following harvest. Over the next 50 years, volume is projected to greatly increase. However, both dwarf mistletoe and root disease remain a part of the stand projection, even when the stumps are removed. After 60 years, the projected volume in both stands is declining due to disease impacts (figs. 8 and 9). The number of infection centers in the stand is recomputed for the year 2020. Without the removal of infected stumps, many small centers are simulated to be around remaining infected stumps. Removal of stumps reduces the expected number of such centers, but has little effect on the total projected area of infection. There is no gain in projected volume through removal of infected stumps. Volume has been harvested and 80 years later the stands are expected to be in much the same condition as they were in 1990. Thus, in terms of disease reduction, overstory removal even with stumping was ineffective.

A clearcut of stand 104 is simulated with and without stump removal. All trees greater than 1 inch diameter are removed and only ponderosa pine is planted back on the site. Trees less than 1 inch diameter were left to simulate natural regeneration on the site. The stand is planted at 500 trees per acre with an expected survival of 90%. This brings the expected stocking to over 2,000 trees per acre, 10 years after harvest. Without sizeable hosts present, root disease presumably dies in much of the stand. The removal of stumps 5 inches diameter or larger further reduces the presence of root disease in the new stand.

Simulated removal of stumps following a clearcut effectively reduces root disease on stand 104. Clearcutting also reduces simulated amounts of dwarf mistletoe in the stand (fig. 10). Neither disease is eliminated, however, because infected trees smaller than 1 inch in diameter and stumps smaller than 5 inches remained after harvest. More complete disease treatments can be simulated. However, this level of treatment appears to be sufficient to reduce the hazard and might reasonably be approached in field operations.

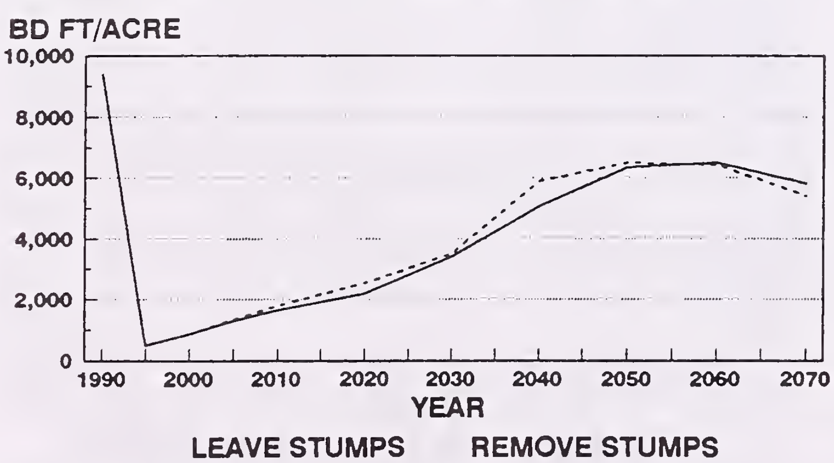

Figure 8.—Stand 103, volume simulation following overstory removal, with and without stump removal.

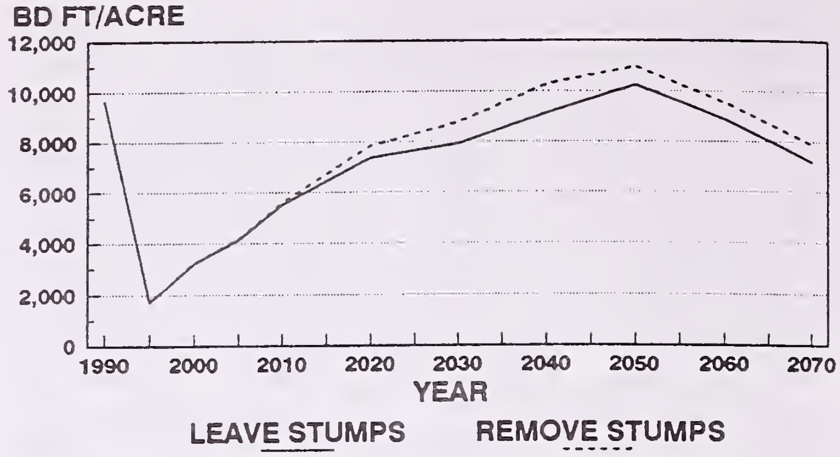

Figure 9.—Stand 402, volume simulation following overstory removal, with and without stump removal.

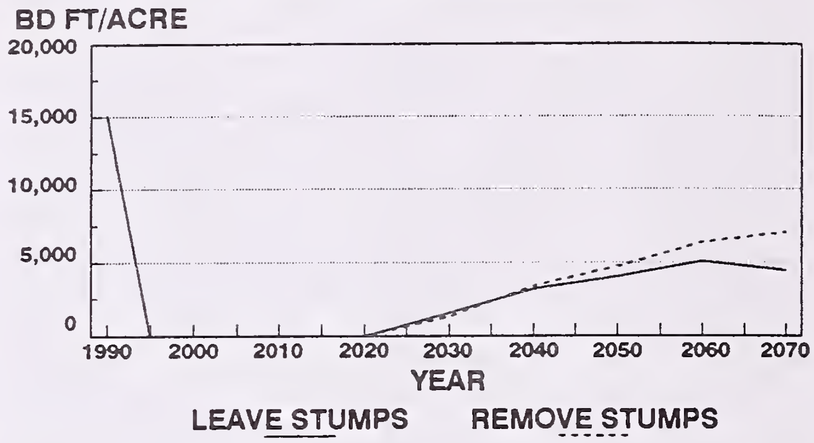

Figure 10.—Stand 104, volume simulation following stand harvest (clearcut), with and without stump removal.

Using the Western Root Disease Model linked to the southwestern ponderosa pine variant of the Prognosis stand growth model, we have simulated a few of the silvicultural treatments one might consider on the Jemez area. In management of such stands, several simulations of each stand should be evaluated, and criteria besides volume need to be used in the decision-making process. However, failure to consider either disease in the planning process would likely result in a failure to obtain the desired future condition.

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Armillaria root disease is a major cause of tree mortality in northern New Mexico. In this paper, we examine various management options for a selected set of ponderosa pine stands infected with *Armillaria*. The Western Root Disease Model is used to simulate management options including removal of infected stumps prior to treatment.

Keywords: root disease, *Armillaria*, simulation, management support systems

Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

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